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Geochemical indicators for mapping of advanced argillic alteration and related alterations in lithocaps

Геохимични индикатори за картиране на интензивната аргилизация и придружаващите хидротермални изменения в литошапките

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Introduction

Hydrothermal alterations are between the most important criteria for prospecting for ore deposits because of close connection of alteration and ore mineralization being parts of the same magmatic-hydrothermal system (Sillitoe, 2010). This close connection is a key for understanding the evolution of magmatic-hydrothermal system. Upper parts of the system, so called “lithocaps”, are object of increasing interest because of big potential for epithermal mineralizations (Hedenquist, Arribas, 2017) and for evaluation of perspectives for development of porphyry deposit in depth (Cooke et al., 2017). The following hydrothermal alterations are typical for lithocaps: silification, advanced argillic, intermediate argillic, sericite and distal propylite. Analysis of mineralogy and geochemistry of advanced argillic alteration (AAA) and related hydrothermal alterations gives reason to propose some elements as geochemical indicators. They can be used for separation of AAA zones and together with other geological data would give prospective for exploration of ore mineralization.

Geochemistry of advanced argillic alteration zones

Over 30 occurrences of AAA are known in Bulgaria (Velinov et al., 2007) some of them associating with porphyry copper and epithermal deposits. They concentrate in the Srednogorie zone, where host rocks are Upper Cretaceous intermediate volcanics and in the Eastern Rhodopes – related to Paleogene andesites and latites. Most of these deposits show a well-expressed hydrothermal alteration zonality. Everywhere AAA is characterized by a well-developed alunite zone, combined in most cases with kaolinite-dickite and silicic zones, less commonly zones with pyrophyllite and diaspore. The transition toward unaltered volcanic rocks is marked by zones of sericitization and/or intermediate argillic alteration and propylitization.

Our previous investigations of AAA in Bulgarian deposits (Hikov, 2004, 2014; Hikov et al., 2010) show that AAA zones characterize with geochemical features which are result of formation in extremely acid conditions and specific mineral composition – alunite, kaolinite, dickite, diaspore, pyrophyllite, APS minerals, zunyite, rutile, etc. Most of chemical elements (Rb, Cs, Mn, Ni, Co, Zn, Y, HREE, etc.) are very mobile and are extracted from altered rocks, only Rb concentrate in sericite rocks. Other elements like Sr, to a lesser extent P, Pb, LREE, concentrate in AAA zones due to their including in alunite and APS minerals (mainly svanbergite, svanbergite-woodhouseite solid solutions, woodhouseite, rarely florencite). Ti, V, Zr, Hf, Ga, Nb, Ta, Th, U, etc. are inert in these zones and take part in rutile and residual zirconium phases. All these minerals remain stable during weathering and allow trace elements to be used for geochemical prospecting. On the other hand the alunite geochemistry (concentration of Sr, Pb, La, Ce, etc.) is known as a vector to the mineralized center (Chang et al., 2011).

Geochemical indicators

It was established that the significant enrichment of Sr concentration is characteristic feature of advanced argillic alteration of volcanic rocks (Hikov, 2004). At the same time Sr contents in transitional alteration zones (propylite, intermediate argillic, sericite) are low. Thus Sr can be used for separation of AAA zones from the other hydrothermal alterations (Fig. 1). This is very important in cases with similar mineral composition such as intermediate argillic and kaolinite AAA rocks especially if there were not found other typomorphic minerals. Differentiation of sericite rocks from pyrophylite AAA rocks is also difficult due to similar optic features of the two minerals. In these

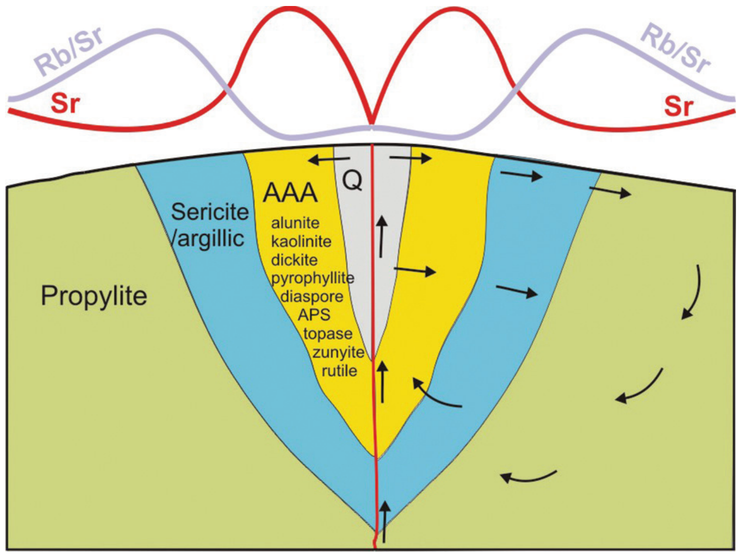

Fig. 1. Schematic model of distribution of Sr and Rb/Sr ratio in typical zoning with advanced argillic alteration: *AAA*, advanced argillic alteration; *Q*, monoquartz (massive silica, vuggy quartz) rocks

cases, Sr concentrations can be used as a "strontium criterion".

Independent geochemical indicator is Rb/Sr ratio (Fig.1). It allows precise separation of sericitic from AAA rocks because of contrasting values in the two alteration types. Anomalously low values of Rb/Sr ratio are typical of AAA zones and suggest high-sulphidation epithermal environment, while high values are characteristic of sericite rocks and could be perspective for prospecting of porphyry copper or low-sulphidation epithermal mineralization (Hikov, 2004).

In some cases the REE patterns can be used as geochemical indicator. REE patterns of AAA rocks are characteristic and different from that of other alteration types: comparatively inert behavior of LREE (sometimes with slight enrichment) while MREE and HREE become mobile and are extracted (Hikov, 2014). Different are the REE patterns of monoquartz rocks (massive silica, vuggy quartz) which show strong depletion of all REE. These most altered rocks contain only inert elements (Hikov, 2015), mark the central parts of hydrothermal systems and may concentrate Au mineralization.

Conclusions

Proposed geochemical indicators can be used for separation of AAA from related hydrothermal alterations in lithocaps. They are a contribution to the known models of geochemical dispersion around porphyry copper deposits (Halley et al., 2015) at their upper levels. They should be used for precise mapping of metasomatic zoning and making correct model of magmatic-hydrothermal systems. They would also be used as vectors to potential ore mineralization and would give prospective for exploration.

References

Chang, Z., J. Hedenquist, N. White, D. Cooke, M. Roach, C. Deyell, J. Garcia, J. B. Gemmell, S. McKnight, A. Cuison. 2011. Exploration tools for linked porphyry and epithermal deposits: Example from the Mankayan intrusion-centered Cu-Au district, Luzon, Philippines. – *Econom. Geol.*, *106*, 1365–1398.

Cooke, D., N. White, L. Zhang, Z. Chang, H. Chen. 2017. Lithocaps – characteristics, origins and significance for porphyry and epithermal exploration. – In: *Proc. of the 14th SGA Biennial Meeting 2017 Mineral Resources to Discover*, *vol. 1*. Quebec City, Canada, 291–294.

Halley, S., J. Dilles, R. Tosdal. 2015. Footprints: Hydrothermal alteration and geochemical dispersion around porphyry copper deposits. – *SEG Newsletter*, *100*, January 2015, 1–17.

Hedenquist, J., A. Arribas. 2017. Epithermal ore deposits: first-order features relevant to exploration and assessment. – In: *Proc. of the 14th SGA Biennial Meeting 2017 Mineral Resources to Discover*, *vol. 1*. Quebec City, Canada, 47–50.

Hikov, A. 2004. Geochemistry of strontium in advanced argillic alteration systems – possible guide to exploration. – In: *Proc. of the Ann. Sci. Conference "Geology 2004"*. Sofia, 29–31.

Hikov, A. 2014. REE mobility during advanced argillic alteration in some epithermal and porphyry copper systems from Central Srednogorie, Bulgaria. – In: *Proc. of the XX Congress CBGA*, *vol. 1*. Tirana, Albania, 154–157.

Hikov, A. 2015. Behaviour of inert (immobile) elements in extremely acid leaching: an example from Asarel porphyry copper deposit. – In: *Proc. of Jubilee National Conference "GEOSCIENCES 2015"*. Sofia, BGS, 65–66.

Hikov, A., C. Lerouge, N. Velinova. 2010. Geochemistry of alunite group minerals in advanced argillic altered rocks from the Asarel porphyry copper deposit, Central Srednogorie. – *Rev. Bulg. Geol. Soc.*, *71*, 1–3, 133–148.

Sillitoe, R. 2010. Porphyry copper systems. – *Econom. Geol.*, *105*, 3–41.

Velinov, I., A. Kunov, N. Velinova. 2007. *The Metasomatic Secondary Quartzite Formation in Bulgaria.* Sofia, Prof. Marin Drinov Academic Publishing House, 198 p.